A Study of Bottom-Trawl Discards in Queen Charlotte Sound and Hecate Strait, 1981 and 1982

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by

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ABSTRACT

Stanley, R. D. 1985. A study of bottom-trawl discards in Queen Charlotte Sound and Hecate Strait, 1981 and 1982. Can. MS Rep. Fish. Aquat. Sci. 1840: 67 p.

The B.C. domestic trawl fishery does not retain all sizes and species of fish which are captured during routine commercial fishing. The fish which are not retained for sale are discarded at sea, often in a stressed, injured or moribund state. The discarded portion is composed of species for which there is a limited or no market, species which are prohibited from retention by trawlers, and non-marketable juveniles.

The amount of discards relative to landings can vary greatly over time and space, and among fisheries for different target species. However, observations from Queen Charlotte Sound and Hecate Strait in 1981 and 1982 indicated that, averaged across trawl fisheries, approximately 40% of the catch was discarded at sea. The quantities of individual species were shown to be large enough to warrant serious consideration by stock assessment biologists.

RÉSUMÉ

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Dans le cadre de la pêche canadienne au chalut pratiquée en C.-B., toutes les tailles et espèces de poissons prises ne sont pas conservées. Le poisson non conservé pour la vente est rejeté à la mer, souvent stressé, blessé ou moribond. La partie non conservée est formée des espèces au marché limité ou inexistant, des espèces interdites pour les chalutiers et des jeunes poissons invendables.

La quantité des rejets par rapport aux débarquements peut varier beaucoup en fonction du temps, de l'espace ainsi que des différentes espèces visées. Toutefois, les observations effectuées dans le bassin Reine-Charlotte et le détroit d'Hécate en 1981 et 1982 indiquent qu'en moyenne, environ 40% des prises des chalutiers étaient rejetées à la mer. Les quantités des différentes espèces rejetées étaient suffisantes pour que les biologistes chargés de l'évaluation du stock les étudient sérieusement.

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INTRODUCTION

This report summarizes the results of a 2-year study (1981-82) of discarding in the domestic trawl fishery in Queen Charlotte Sound and Hecate Strait.

Domestic trawl fishermen discard a significant proportion of their catch. This proportion is composed of: (1) currently non-marketable species such as ratfish (Hydrolagus collei) and butter sole (Isopsetta isolepis); (2) species for which there is only a limited or occasional demand, such as dogfish (Squalus acanthius), various skates, and turbot (Atheresthes stomias); (3) undersized specimens of marketable species which include rock sole (Lepidopsetta bilineata), English sole (Parophyrys vetulus), Pacific cod (Gadus macrocephalus), and sablefish (Anoplopoma fimbria); and (4) species prohibited from retention by trawlers such as halibut (Hippoglossus stenolepis).

The purpose of the study was to estimate the amounts discarded and obtain information on the length and sex composition of the discards. Pacific cod, sablefish, halibut, rock sole, and English sole were the species of most interest. The estimates of halibut discards are presented in a separate report (Stanley 1984).

METHODS

Log-book reports indicated that discards of the priority species were greater in Hecate Strait and highest in the months of May through August. Observer trips were therefore distributed to reflect this effect. Discards were not reported to be significant in the deeper water fishing for Pacific ocean perch, so trips targetting on this species were avoided. Davenport et al. (1983) summarized the distribution of observer trips by time and area, the numbers of biological samples taken, and the sampling methodology.

I estimated total fleet discards by prorating observed discard ratios of all species (amount of each species discarded / amount of all species kept) for each target category by total fleet landings for each target category. Target species in observed tows was characterized as the most abundant species in the retained catch. For example, in one area-time cell, the discard ratio of juvenile English sole during Pacific cod fishing was calculated as the total weight of discarded English sole divided by the total weight of retained catch (of all species) in those tows where Pacific cod was the most abundant species by weight in the retained catch. This discard ratio was then multiplied by the total fleet landings of all species from tows when Pacific cod was the most abundant species for the same area-time cell.

The potential exists for calculation of the corresponding confidence limits about the calculations (Saila 1983). This was attempted with the same data base by Stanley (1984) for halibut discards. Were individual tows to be independent, then such a statistical analysis would be appropriate for the present report. However, because of net (mesh size, design, etc.), vessel, and skipper effects, tows are not independent thus the actual sampling unit is a trip. With only 33 trips divided among two years, two areas, two seasons, and six target groups, the confidence limits would be very large and have little validity. Furthermore, the level of coverage as a percent of landings was low enough that representativeness for many of the area-time-target cells is questionable, as shown in Stanley (1984). Except for one example discussed later, fiducial limits were not calculated because I believed they would not represent the true precision.

"Seasons" were defined as "summer" (May-August) and "winter" (Sept-April). Biological samples of priority species were collected when possible. Pre-sort samples represented the size and sex compositions of fish as it was landed on deck, prior to sorting by fishermen. "Discard" and "keeper" samples were collected after sorting by fishermen. Observers attempted to make samples as representative as possible by working vertically through the pile. There was no opportunity for more rigorous sampling without interfering with the commercial operation.

RESULTS

ACCURACY OF VISUAL ESTIMATES

The two principal sources of error in the estimation of total fleet discards lie in firstly estimating the discards for each observed trip and secondly in extrapolating these results to total fleet activities.

The former source of error was examined in two ways. Figures 1 to 5 illustrate observer estimates by selected species or species groups for a whole trip plotted against the plant tally figure. Some species are grouped because they were grouped on tally slips. While there is some imprecision, there seemed to be no serious bias. Sole and Pacific cod estimates were accurate but there was some tendency to over-estimate skates, rockfish, and lingcod.

We also examined the observers' abilities to estimate individual catches during 30 tows of a charter. Figures 6 to 13 plot the estimates made by the 3 principal observers of the study against actual catch for selected species. Table 1 presents the regression statistics. Table 2 summmarizes total catch by species for all 30 tows. The imprecision in estimating minor components of less than 1400 kg is shown in Figure 14. Figure 15 shows the imprecision in estimating catches of 250 to 17,000 kg. As observed for the commercial trips, estimates of minor components were much less precise. The relative variance decreased with increasing total catch. I had initially

planned to use the charter results to derive correction formulae for the visual estimates of each species. However, since the formulae are partially a function of the ranges of weights in the calibration set, they cannot be applied to adjust field observations which exceed that range.

The degree of overall bias is constrained by the accuracy with which observers estimate the total catch. Most skippers have a good knowledge of what is contained in a normal "split" or "lift", so the most significant source of error lies in the apportioning by species from the gross total. Table 2, which contains the total estimates by species, shows that no major biases were observed between fish groups as for example overestimating round fish at the expense of flatfish. There did not appear to be significant bias in the estimation of discards provided the quantities within the catch were significant so I used the estimates directly as reported.

OBSERVER COVERAGE

The representativeness of the observed trips to the fleet as a whole can be examined in Tables 3 and 4. Table 3 shows that observed trips were generally as productive as the overall fleet. One exception was the "others" category. This category reflected in observed trips a miscellaneous grouping of often relatively unsuccessful tows. Incidental species such as rex sole or skates were often the dominant commercial species. For the overall fleet, it more frequently represented successful tows for lingcod or even dogfish. This may have led to an overestimate of the ratio of discards within this category which accounted for 13% of the landings.

The observer coverage for each fishery is shown in Table 4. Table 5 summarizes the sample sizes. As discussed earlier, if one assumes that net, boat, and skipper effects are important in determining catch composition then each tow is not independent and "trip" must be the basic sampling unit. Table 5 shows that sample sizes using trip as an observation were too small for normal statistical procedures. While no clear sources of bias are suspected, the limited sample size and low level of coverage suggests that the proration to total fleet results should be taken as qualitative assessments. The limited amount of sampling suggests that as comparative sources of imprecision, the proration to total fleet results would be a more serious concern than the error in estimating the results of individual observer trips.

Reasonable estimates of the discard ratio could have been obtained with more intensive sampling. Table 6 summarizes the sample sizes required to have estimated the ratio of English sole discards to keepers by season and year. The estimates of mean and variance were derived through application of the Bootstrap technique (Efron 1982). Projected sizes take into account the actual total number of landings $[n=n_0/(1 + n_0/N)]$.

The summer, 1981 calculation is anomalous, the result of the single, very large landing of the second data pair which distorts the ratio estimator.

The other 3 estimates are probably more realistic and indicate that while a ± 10% error is unrealistic, an error of ± 25% could be achieved for this estimator with between 10 and 30 trips per season.

TOTAL DISCARD ESTIMATES

The estimates of total discards over 1981 and 1982 by the trawl fleets are shown in Table 7 to 10. Table 11 summarizes the estimates by discard species for the two areas and divides the sums in half to reflect annual estimates.

I have omitted estimates of rockfish discards from the summary in Table 11 because very few observations were collected from these fisheries. The ratios for these shown in Table 6-9 are probably overestimated as comments from fishermen and research cruises have indicated relatively low discard rates in these fisheries. Landings of rockfish are included in Table 11 in order to show all landings from these areas.

SIZE AND SEX COMPOSITION

Appendix Tables 1-6 summarize the biological data. Columns noted as "M + F" include all observations.

LOG BOOK REPORTS OF DISCARDS

The groundfish data base at PBS, Nanaimo includes trawl skipper's comments on quantities discarded along with landing data. It has been assumed that not all discarding is reported in these figures as the details on discards as recorded in log-books vary among skippers and for different species. This information has in the past however represented the only information available and the question has been raised as to whether the figures could be used as minimum estimates. The estimates presented by the current study provide an opportunity to compare the present estimates of total discards with estimates that could be inferred from log-book comments. Table 12 summarizes the comparisions. As minimum estimates, totals derived from log-book coverage range from 2 to 20% of the observer estimates. Log-book observations should therefore only be used to examine when and where discarding takes place but not for assessing the magnitude. Log-book discards by species for Queen Charlotte Sound and Hecate Strait combined are summarized for 1977-1982 in Table 13.

DISCUSSION

GENERAL

The purpose of this study was to produce estimates of the general magnitude of the discards. Table 11 shows that discarded quantities of some species equal the quotas and yields which currently apply to many of the groundfish fisheries on the B.C. coast. The observations indicate that 40% of the fish brought on board may be discarded at sea. Very few studies have examined the viability of these discards but mortality could be assumed to range from: close to 100% for turbot, rockfish, and juvenile Pacific cod, 50 to 100% for juvenile sole and sablefish; and equal 50% for halibut (Hoag 1975). The overall exploitation suggests that the impact of bottom-trawling on the fisheries ecology of B.C. waters is seriously under-represented through use of landing statistics alone.

The estimates of discards for individual species is of even greater concern to stock assessment biologists. Examined individually, the discard rates by species pose some assessment and management problems. Trawl-caught dogfish and turbot from Hecate Strait and Queen Charlotte Sound have usually been discarded and in recent years landings from these areas have remained low. In the absence of discard information, assessment biologists could easily assume that the stocks are in an unexploited condition with respect to biomass and age compositon. In fact, both these stock may be being subjected to annual removals in the thousands of tonnes. Harvest rates for these stocks are of less concern at present but the exploitation histories would become important if the markets change.

PACIFIC COD

Table 11 indicates that discards of juvenile Pacific cod were relatively low in comparison with landings of adult fish, but actual abundance of juvenile cod was very low in 1981 and 1982 (Westrheim 1985). Trawl skippers have reported in earlier years that discarding of juvenile Pacific cod can reach significant levels. Using log-book reports as a relative index, trawl skippers in 1979 reported a quantity of discarded Pacific cod 14 times greater than they reported in 1981-82. This implies discarding of thousands of tonnes in 1979. The impact of discarding on Pacific cod stocks can only be assessed if observations are collected as the large year-classes pass through the fishery as juveniles. This was not possible for the present study. Discard rates cannot be directly extrapolated from one year to the next on the basis of relative abundance. They are a function of, among other things, the degree to which juveniles aggregate with the adults. This relationship could be expected to vary with the relative abundance of each age group.

SABLEFISH

I estimated sablefish discards to be approximately 1000 t per year during the study period for Queen Charlotte Sound and Hecate Strait combined. This compares with log-book observations which averaged 150 t. The 1000 t of juveniles for the study period is significant relative to the current adult quota of 3500 t. Even more interesting is 1979, in which 1662 t were reported in log-books. If the same percentage of sablefish discards was reported in 1979 then total sablefish discards in that year could have exceeded 11,000 t for these two regions alone although this assumes that the percentage of reported discards in logbooks does not change with the magnitude of discards. Fishermen may report a higher percentage as the incidence increases. As for Pacific cod, the true impact of discarding on sablefish can only be assessed if observations are collected while the large year-classes move through the juvenile phases.

ROCK SOLE

Rock sole discards were not as significant as for English sole in the 1981 and 1982 observations. Fishermen have in the past reported discarding to be a problem in certain areas. This led in part, to the closed area off Cumshewa (Fargo 1985). Based on 1981 and 1982 observations, the problem in rock sole would not seem severe, but log-book reports of discards in 1981-82 only equalled 40% of the 1977-80 average. This parallels the sablefish and Pacific cod results and implies that the timing of this program did not coincide with the years when discarding of juvenile rock sole could have had a major impact on the fishery.

ENGLISH SOLE

Table 10 indicates that discards of juvenile English sole were significant compared with current yields. Averaged over 2 years, 46% by weight of the captured English sole were discarded. No studies have focussed on the viability of discarded English sole, but early tagging experiments revealed that recoveries were negligible unless the time and handling was reduced significantly from procedures normally used in commercial fishing (K. Ketchen, pers. comm.).

The English sole length frequency observations were separated into ages with an age-length key. The data were then used to estimate the impact of discarding on the yield. Assuming a 90% mortality rate, if the estimated levels in 1981 and 1982 represented the average conditions then this added source of mortality could reduce average yield by 30%. This result was corroborated in yield/recruit simulations (Fargo 1985). Log-book records indicated that 1981 and 1982 were average in terms of reported discards of English sole (Table 13).

One of the factors which affects discarding is the mesh size of the trawl net. Figure 16 plots mean size of the English sole caught during a trip against the codend mesh size reported by the skipper. The data are not presented as measures of selectivity but to show the effect that the variation in mesh sizes currently used in the fishery can have on discarding. Had the program continued, the additional data could have made it possible to derive selectivity curves for some of the important species.

Jeff Fargo (P.B.S., Nanaimo) and I also used the discard estimates and size composition data to assess how a lack of discard information might affect catch-at-age analysis. We were concerned that if yearly effort varied enough, then discarding could alter incoming year-class strengths such that their abundance at the time of full recruitment and appearance in landed samples would not reflect initial abundance. This effect could negate any reasonable attempt to correctly identify environmental or population correlates of successful recruitment.

While discards of English sole clearly added variability in an attempt to analyze recruitment, the results suggested that relative year-class strengths should still be identifiable in catch-at-age analysis of landings data. Real year-class variation tended to overwhelm the variability in mortality introduced by discarding. The fact that discarding was spread over 2-3 years of a juvenile sole's life led to a smoothing effect on discard induced mortality. Discard mortality therefore represented a relatively constant source of juvenile mortality in English sole.

A final observation concerns the change by the processors in 1982 to request a minimum size of 14 inches (35 cm). The effect on the size composition of landed samples is demonstrated in Appendix Tables 5 and 6. Use of landed samples for length frequency analysis must pay close attention to variations in market size limits. It further underlines the need for background information on mesh selectivity; information that could apparently be obtained as an anciliary result of a discard program.

CONCLUSION

This initial study has provided a first estimate of the magnitude of the discard problem. Its principal objective was to allow investigators to determine the extent to which the current stock assessment and management techniques are still appropriate in the absence of discard information. Discard information has been shown to be critical to the management of a number of species, although a proper assessment requires monitoring during years of peak juvenile abundance.

Should this presentation or subsequent trends in the fishery lead to renewed interest, a number of options are available. General magnitude and size composition can be examined by monitoring over broad areas as was initially planned for this study. Such a format might be fine-tuned to provide measures of relative year-class strength for those important species

which appear as juveniles in the discards. A different set of options could involve more rigorous high resolution studies which would focus on one or two species by concentrating on certain area/season cells. These kinds of studies might warrant a more rigorous on-board sampling procedure. Consideration should also be given to some form of viability study. However, both configurations require a long-term commitment in order that the larger year-classes can be observed.

Finally, a movement toward more processing at sea and other changes in the fishery will gradually increase the need for sea sampling. Discard observations and traditional biological sampling could easily be combined into a multi-faceted observer program as is done on the east coast of Canada (Kulka and Waldron 1983).

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REFERENCES

Davenport, D. J., J. R. Selsby, and R. D. Stanley. 1983. An inventory of groundfish samples collected by observers on domestic trawlers off Canada's Pacific coast, 1981-1982. Can. Data Rep. Fish. Aquat. Sci. 405: 35 p.

Efron, B. 1982. The jackknife, the bootstrap and the resampling plans. Soc. Ind. Appl. Math., Phil., Pa.

Fargo, J. 1985. 4. Flatfish. In Tyler, A. V. and G. A. McFarlane (eds.). Groundfish stock assessments for the west coast of Canada in 1984 and recommended yield options for 1985. Can. MS Rep. Fish. Aquat. Sci. 1813: 353 p.

Hoag, Stephen H. 1975. Survival of halibut released after capture by trawls. Int. Pac. Halibut Comm. Sci. Rep. 57: 18 p.

Kulka, D. S. and D. Waldron. 1983. The Atlantic observer programs - a discussion of sampling from commercial catches at sea, p. 255-262. In W. G. Doubleday and D. Rivard [ed.]. Sampling commercial catches of marine fish and invertebrates. Can. Spec. Publ. Fish. Aquat. Sci. 66.

Saila, S. B. 1983. Importance and assessment of discards in commercial fisheries. FAO Fish. Circ., (756): 62 p.

Stanley, Richard D. 1984. Incidental catch of halibut (Hippoglossus stenolepis) by domestic trawlers in Queen Charlotte Sound and Hecate Strait, in 1981 and 1982. Can. Tech. Rep. Fish. Aquat. Sci. 1318: 45 p.

Tyler, A. V. and G. A. McFarlane. (Editors). 1985. Groundfish stock assessments for the west coast of Canada in 1984, and recommended yield options for 1985. Can. MS Rep. Fish. Aquat. Sci. 1813: 353 p.

Westrheim, S. J. 1985. 3. Pacific cod. In Tyler, A. V. and G. A. McFarlane (eds.). Groundfish stock assessment for the west coast of Canada in 1984 and recommended yield options for 1985. Can. MS Rep. Fish. Aquat. Sci. 1813: 353 p.

Table 1. Regression analyses of observer estimates versus actual weights by each tow for important species.

	Distribution of actual weights (kg)			Log transformation of estimated vs actual weight	Non-transformed predictive regression of actual vs estimated weight			
							Predicted actual weight (kg) for specified estimated weight (kg)	
	n	$\bar{x}$	maximum	r^2	slope	intercept	100 kg.	1000 kg.
Dogfish	84	313	2,956	0.831	0.966	29.6	126	996
Skates	81	177	768	0.619	0.803	44.7	125	848
Ratfish	36	47	361	0.751	1.052	9.5	115	1062
Pacific cod	90	497	3,705	0.692	1.064	-32.8	74	1031
Pollock	75	167	1,772	0.730	0.970	16.5	114	986
Rockfish	153	18	198	0.668	0.325	10.8	43	336
Sablefish	57	131	2,277	0.628	0.963	8.9	105	972
Lingcod	84	45	198	0.560	0.606	14.2	75	620
Turbot	90	381	3,111	0.794	0.977	22.1	120	999
Rex sole	48	48	178	0.501	0.753	23.6	99	777
Butter sole	81	38	283	0.556	0.867	10.4	97	877
Rock sole	63	50	351	0.585	0.729	6.7	80	736
English sole	90	140	638	0.773	0.748	42.5	117	790

Table 2. Actual and estimated total weight (kg) by species from 30 tows aboard a charter vessel.

Species	Actual weight	Observer #1	Observer #2	Observer #3
Dogfish (Squalus acanthius)	8,756	8,871	7,293	8,456
Skates (Raja sp.)	4,662	3,281	4,706	4,929
Ratfish (Hydrolagus collei)	560	527	322	417
Pacific cod (Gadus macrocephalus)	14,922	14,462	13,995	16,372
Pollock (Theragra chalcogramma)	4,171	4,140	3,635	3,851
Pacific ocean perch (Sebastes alutus)	49	42	45	24
Redbanded rockfish (Sebastes babcocki)	57	41	23	117
Silvergray rockfish (Sebastes brevispinis)	176	220	134	124
Bocaccio (Sebastes paucispinis)	73	46	58	102
Canary rockfish (Sebastes pinniger)	29	14	13	22
Shortspine thoryhead (Sebastolobus alascanus)	57	38	47	47
Lingcod (Ophiodon elongatus)	1,257	1,408	1,395	1,443
Arrowtooth flounder (Atheresthes stomias)	11,422	11,665	10,228	11,153
Petrale sole (Eopsetta jordani)	102	50	11	3
Rex sole (Glyptocephalus zachirus)	762	467	301	751
Pacific halibut (Hippoglossus stenolepis)	5,174	4,280	4,357	4,950
Butter sole (Isopsetta isolepis)	1,016	1,015	696	835
Rock sole (Lepidopsetta bilineata)	1,046	1,319	1,322	1,096
Dover sole (Microstomus pacificus)	246	421	279	318
English sole (Parophrys vetulus)	4,192	3,554	4,354	3,785
Starry flounder (Platichthys stellatus)	472	507	467	615

Table 3. Comparison of CPUE (lb/hr) between total fleet and observed trips (1981 and 1982) (from Stanley 1984).

	Queen Charlotte Sound				Hecate Strait			
	Summer		Winter		Summer		Winter	
	Fleet	Observed	Fleet	Observed	Fleet	Observed	Fleet	Observed
Pacific cod	1,334	1,149	1,465	1,859	1,668	1,204	1,456	1,164
Rockfish	1,457	1,252	1,748	2,138	1,670	1,378	2,490	1,217
Pacific ocean perch	3,780	574	4,779	-	3,944	1,106	2,081	99
Turbot and Dover sole	2,076	2,282	4,035	6,882	1,763	1,548	1,706	1,968
English and rock sole	871	926	835	993	1,279	827	1,008	851
Others	1,035	764	1,174	781	2,251	560	1,791	1,262

Table 4. Comparison of landings observed with total fishery landings by area, season and target group (1981 and 1982) (from Stanley 1984).

	Total landings (lb)	Observed landings (lb)	% observed
	QUEEN CHARLOTTE SOUND		
Summer			
Pacific cod	2,128,348	35,485	1.67
Rockfish	2,232,868	99,301	0.44
Pacific ocean perch	10,039,307	2,843	0.03
Turbot and Dover sole	1,347,473	25,536	1.90
Rock and English sole	879,315	31,862	3.62
Others	3,178,505	52,815	1.66
Total	19,805,816	247,842	1.25
Winter			
Pacific cod	940,608	63,825	6.79
Rockfish	4,066,749	69,151	1.70
Pacific ocean perch	3,283,021	0	0.00
Turbot and Dover sole	270,324	19,513	7.22
Rock and English sole	288,771	5,308	1.84
Others	1,800,496	6,087	0.34
Total	10,649,969	163,884	1.54

Table 4 (cont'd)

	Total landings (lb)	Observed landings (lb)	% observed
	HECATE STRAIT		
Summer			
Pacific cod	7,213,374	141,883	2.00
Rockfish	1,233,051	10,529	0.85
Pacific ocean perch	6,721,324	6,820	0.10
Turbot and Dover sole	3,283,471	51,376	1.56
Rock and English sole	2,550,861	67,120	2.63
Others	1,343,973	8,958	0.67
Total	22,346,054	286,686	1.28
Winter			
Pacific cod	6,369,229	136,963	2.15
Rockfish	1,750,517	13,713	0.78
Pacific ocean perch	1,338,395	82	0.00
Turbot and Dover sole	1,047,500	105,756	10.10
Rock and English sole	2,928,036	31,483	1.08
Others	2,921,480	53,463	1.83
Total	16,355,157	341,460	2.09

Table 5. Number of observed tows and trips in which specific target categories of tows were observed.

Area	Season	Target	Trips	Tows
Q. C. Sound	Summer	Pacific cod, English sole, rock sole	5	45
"	"	Rockfish	5	52
"	"	POP	2	4
"	"	Turbot, Dov. sole	2	13
"	"	Others	5	50
Q. C. Sound	Winter	Pacific cod, Eng. sole, rock sole	6	39
" "	"	Rockfish	6	33
"	"	POP	0	0
"	"	Turbot, Dover sole	1	3
"	"	Others	4	11
Hecate Strait	Summer	Pacific cod, Eng. sole, rock sole	11	194
"	"	Rockfish	4	9
"	"	POP	1	7
"	"	Turbot, Dover sole	6	39
"	"	Others	9	28
Hecate Strait	Winter	Pacific cod, English sole, rock sole	14	167
"	"	Rockfish	7	13
"	"	POP	1	1
"	"	Turbot, Dover sole	6	47
"	"	Others	11	48

Table 6. Number of observer trips required to estimate the ratio of English sole discards to keepers with 10% or 25% confidence limits (α=0.05).

Discards (kg)	Keepers (kg)	Ratio ($\bar{x}$)	Ratio (S^2)	Required sample size (α=.05) ± 10%	± 25%
Summer, 1981					
318	965				
15,036	26,159				
472	2,835	0.517	0.0106	n=8	n=2
1,039	1,021				
386	75				
2,490	3,769				
154	2,114				
Winter, 1981					
181	344				
293	298				
4,105	1,633				
3,512	745	0.570	0.3251	n=108	n=30
2,385	1,087				
494	1,116				
367	1,565				
70	95				
Summer, 1982					
2,660	865				
3,170	920				
220	151				
7,625	1,736	2.294	0.8648	n=55	n=18
676	918				
2,685	200				
1,775	3,825				
93	440				
Winter, 1982					
6,069	3,093				
513	2,495				
2,261	392				
5,631	1,361	1.440	0.3835	n=62	n=15
683	4,763				
1,132	687				
247	302				
2,910	1,227				

Table 7. Estimated total discards in metric tonnes, 1981 and 1982 combined, summer, Queen Charlotte Sound.

Species	Target species					
	Pacific cod English sole Rock sole	Rockfish	Pacific Ocean perch	Turbot Dover sole	Other	Total
Dogfish	143.2	15.3	334.8	17.5	20.0	530.8
Skate	343.4	39.2	134.6	6.6	204.5	728.3
Ratfish	6.3	8.0	0.0	4.1	9.1	27.5
Salmon	0.0	0.5	0.0	0.0	0.2	0.7
Pacific cod	20.9	10.3	0.0	4.2	27.4	62.8
Pollock	0.0	15.4	21.8	0.3	0.6	38.1
Pacific ocean perch & rockfish	0.2	7.2	4381.4	6.7	4.7	4400.2
Sablefish	92.7	191.6	411.2	8.9	148.3	852.7
Lingcod	17.2	6.5	18.2	6.0	146.0	193.9
Turbot	133.6	208.3	2823.9	361.2	387.2	3914.2
Rex sole	7.9	6.7	0.0	4.3	33.8	52.7
Halibut	220.5	43.1	0.0	1.3	161.7	426.6
Rock sole	105.6	3.4	0.0	1.7	65.2	175.9
Dover sole	4.1	3.5	123.7	73.0	1.9	206.2
English sole	57.8	7.8	0.0	6.4	38.5	110.5
Other flatfish	29.5	0.7	0.0	1.2	12.7	44.1
Misc	29.4	0.7	0.0	0.3	12.2	42.6
Total	1212.3	568.2	8249.6	503.7	1274.0	11807.8

Table 8. Estimated total discards, in metric tonnes, 1981 and 1982 combined, winter, Queen Charlotte Sound.

Species	Target species: Pacific cod English sole Rock sole	Rockfish	Turbot Dover sole	Other	Total
Dogfish	323.6	338.3	18.9	1210.8	1891.6
Skate	40.2	117.3	7.8	160.4	325.7
Ratfish	4.2	14.7	0.2	91.2	110.3
Salmon	0.0	0.4	0.0	0.6	1.0
Pacific cod	31.5	29.3	0.4	14.0	75.2
Pollock	0.1	0.1	0.1	1.8	2.1
Pacific ocean perch & rockfish	6.0	39.2	0.0	22.7	67.9
Sablefish	1.9	4.6	1.0	5.2	12.7
Lingcod	2.4	6.1	0.0	33.5	42.0
Turbot	55.0	86.9	2.9	86.0	230.8
Rex sole	0.9	11.9	0.0	14.0	26.8
Halibut	23.3	40.8	3.0	91.3	158.4
Rock sole	4.5	0.0	0.0	18.9	23.4
Dover sole	0.4	0.5	0.0	0.6	1.5
English sole	4.0	6.2	0.0	35.4	45.6
Other flatfish	0.9	2.8	0.0	20.4	24.1
Misc	45.5	26.3	0.0	0.0	71.8
Total	544.4	725.4	34.3	1806.8	3110.9

Table 9. Estimated total discards in metric tonnes, 1981 and 1982 combined, summer, Hecate Strait.

Species	Target species					
	Pacific cod English sole Rock sole	Rockfish	Pacific Ocean perch	Turbot Dover sole	Other	Total
Dogfish	738.8	990.0	26.4	357.5	412.5	2524.9
Skate	751.9	6.8	65.0	30.2	502.7	1356.6
Ratfish	126.3	8.8	0.0	49.0	32.4	216.5
Salmon	2.5	0.0	0.0	0.0	1.4	3.9
Herring	0.4	0.0	0.0	0.0	0.1	0.5
Pacific cod	168.3	0.2	0.0	11.3	36.2	216.0
Pollock	74.6	0.2	3.0	6.7	0.9	85.4
Pacific ocean perch & rockfish	11.1	8.6	95.5	12.7	1.4	129.3
Sablefish	102.3	9.3	537.5	494.7	8.1	1151.9
Lingcod	9.1	0.0	0.0	1.8	1.9	12.8
Turbot	1014.8	201.8	681.8	716.9	212.6	2827.9
Rex sole	45.7	4.6	100.6	63.4	6.1	220.4
Halibut	270.6	33.6	17.7	83.2	113.0	518.1
Rock sole	140.7	0.0	0.0	0.3	4.6	145.6
Dover sole	8.2	0.6	8.8	72.3	22.7	112.6
English sole	483.3	0.9	0.4	3.6	12.6	500.8
Other flatfish	138.9	0.2	24.4	2.7	12.9	179.1
Dungeness crab	1.3	4.0	0.0	0.0	0.0	5.3
Misc	506.0	1.2	0.0	3.9	6.1	517.2
Total	4594.8	1270.5	1561.1	1910.2	1388.2	10724.8

Table 10. Estimated total discards in metric tonnes, 1981 and 1982 combined, winter, Hecate Strait.

	Hecate Strait Winter					
	Target species					
Species	Pacific cod English sole Rock sole	Rockfish	Pacific Ocean perch	Turbot Dover sole	Other	Total
Dogfish	997.5	180.9	1351.9	63.9	999.3	3593.5
Skate	1275.2	332.3	0.0	16.9	475.6	2100.0
Ratfish	218.7	12.5	0.0	93.0	50.4	374.6
Salmon	0.7	0.7	0.0	0.0	0.0	1.4
Herring	0.6	0.0	0.0	0.0	0.0	0.6
Pacific cod	294.7	10.3	0.0	2.2	22.6	329.8
Pollock	100.6	2.8	0.0	1.5	34.5	139.4
Pacific ocean perch & rockfish	11.1	24.1	0.0	0.9	0.3	36.4
Sablefish	100.5	1.4	0.0	5.9	10.9	118.7
Lingcod	11.3	0.3	0.0	0.5	7.5	19.6
Turbot	1633.8	492.3	642.2	243.9	876.1	3888.3
Rex sole	102.9	20.1	67.6	5.2	42.7	238.5
Halibut	377.4	34.7	67.6	11.7	59.3	550.7
Rock sole	114.3	38.4	0.0	0.2	3.6	156.5
Dover sole	68.3	4.1	101.4	10.3	13.8	197.9
English sole	636.2	81.2	67.6	1.2	70.4	856.6
Other flatfish	136.3	0.5	0.0	1.8	23.8	162.4
Dungeness crab	1.2	0.0	0.0	0.0	0.0	1.2
Misc	225.4	0.0	0.0	0.6	65.0	291.0
Total	6306.7	1236.6	2298.3	459.7	2755.8	13057.1

Table 11. Estimated annual trawl discards by species for Queen Charlotte Sound and Hecate Strait combined based on 1981 and 1982 observations.

	Estimated annual discards (t)	Total trawl landings (t)	
	Total	1981	1982
Dogfish	4,270	37	331
Skate	2,255	215	102
Ratfish	364	-	-
Salmon	4	-	-
Herring	1	-	-
Pacific cod	342	4,033	2,659
Pollock	133	654	814
Other rockfish	-[a]	2,544	2,773
Pacific ocean perch	-[a]	3,847	4,502
Sablefish	1,068	76	62
Lingcod	134	986	1,238
Turbot	5,430	816	432
Rex sole	269	188	72
Rock sole	251	917	636
Dover sole	259	845	535
English sole	758	1,351	449
Other flatfish	205	299	232
Dungeness crab	3	-	-
Miscellaneous	461	-	-
Total (excluding rockfish, and Pacific ocean perch)	18,524	23,228	22,112

[a]Reliable estimates not available.

Table 12. Comparison of average annual discards from log-book observations for 1981 and 1982 versus estimates derived from observer data for 1981 and 1982.

Species	Log-book observations (t)	Prorated observer estimates (t)	Percent reported in log-books
Dogfish	857	4,270	20
Skates	58	2,256	3
Pacific cod	22	342	6
Sablefish	151	1,068	14
Turbot	891	5,430	16
Rock sole	13	250	5
Dover sole	4	259	2
English sole	68	758	9

Table 13. Total discards (t) at sea as reported in log-books for Queen Charlotte Sound and Hecate Strait (1977-1982).

	1977	1978	1979	1980	1981-82
Pacific cod	178	104	302	86	21
English sole	22	51	78	185	68
Rock sole	24	41	27	39	13
Sablefish	9	286	1,662	1,111	150

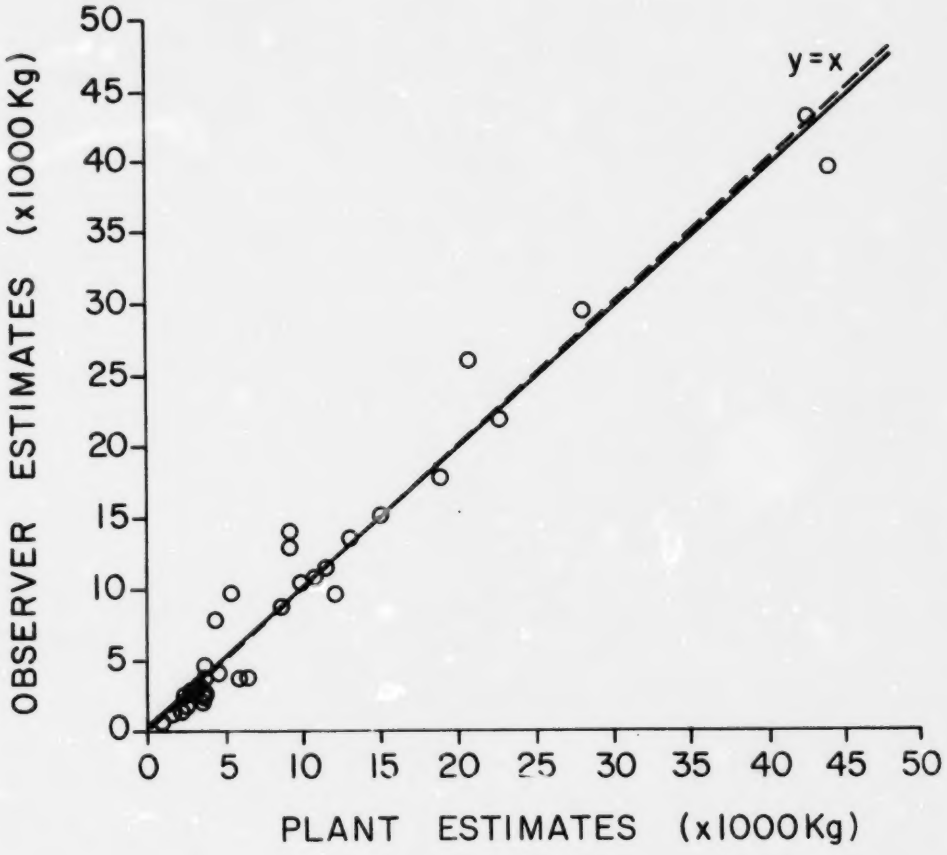

Fig. 1. Observer estimates versus fish plant estimates for Pacific cod.

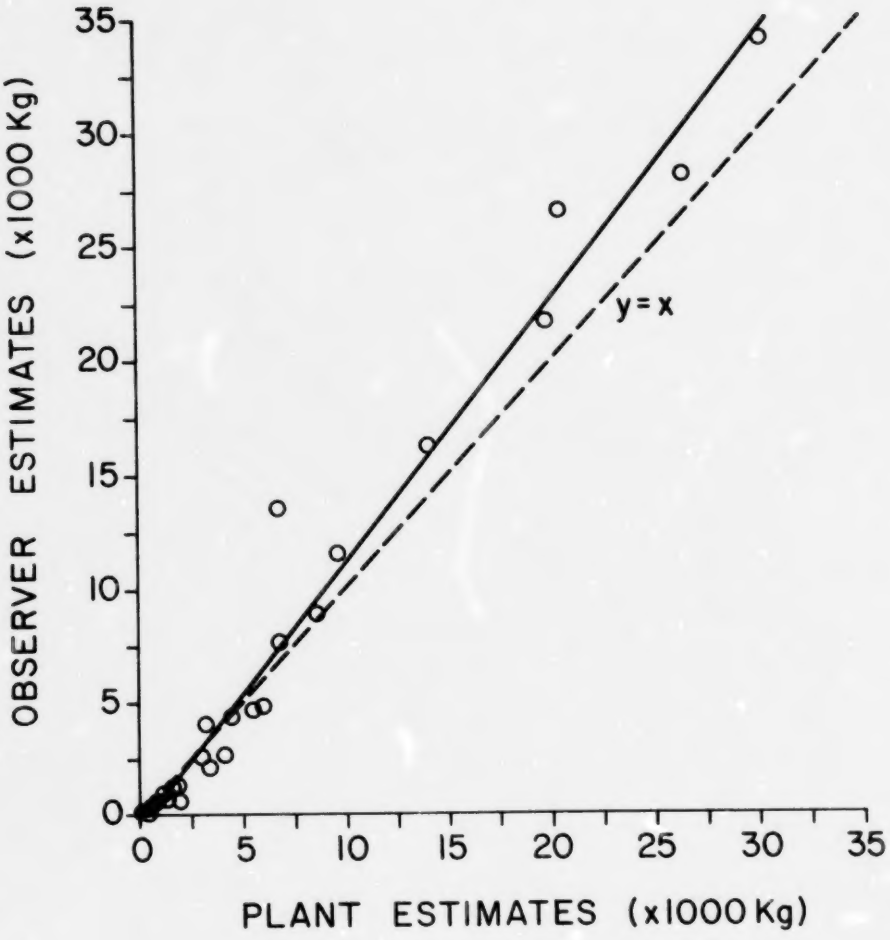

Fig. 2. Observer estimates versus fish plant estimates for rockfish.

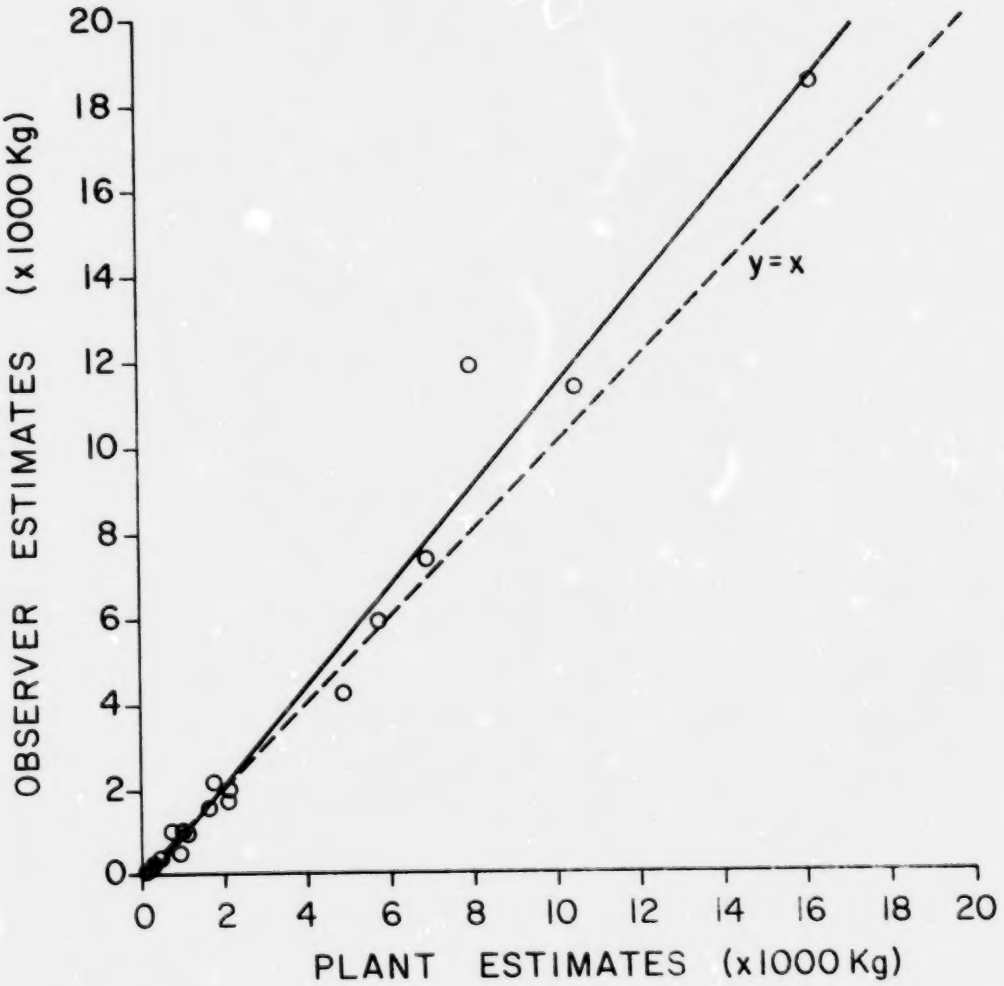

Fig. 3. Observer estimates versus fish plant estimates for lingcod.

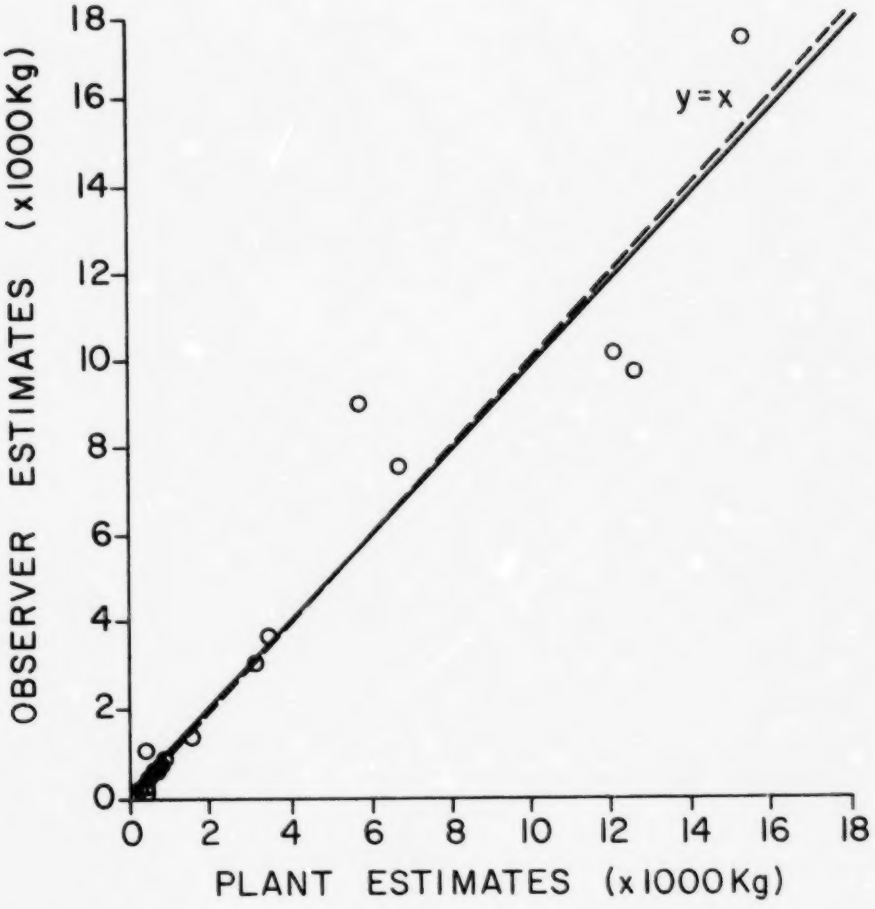

Fig. 4. Observer estimates versus fish plant estimates for rock sole.

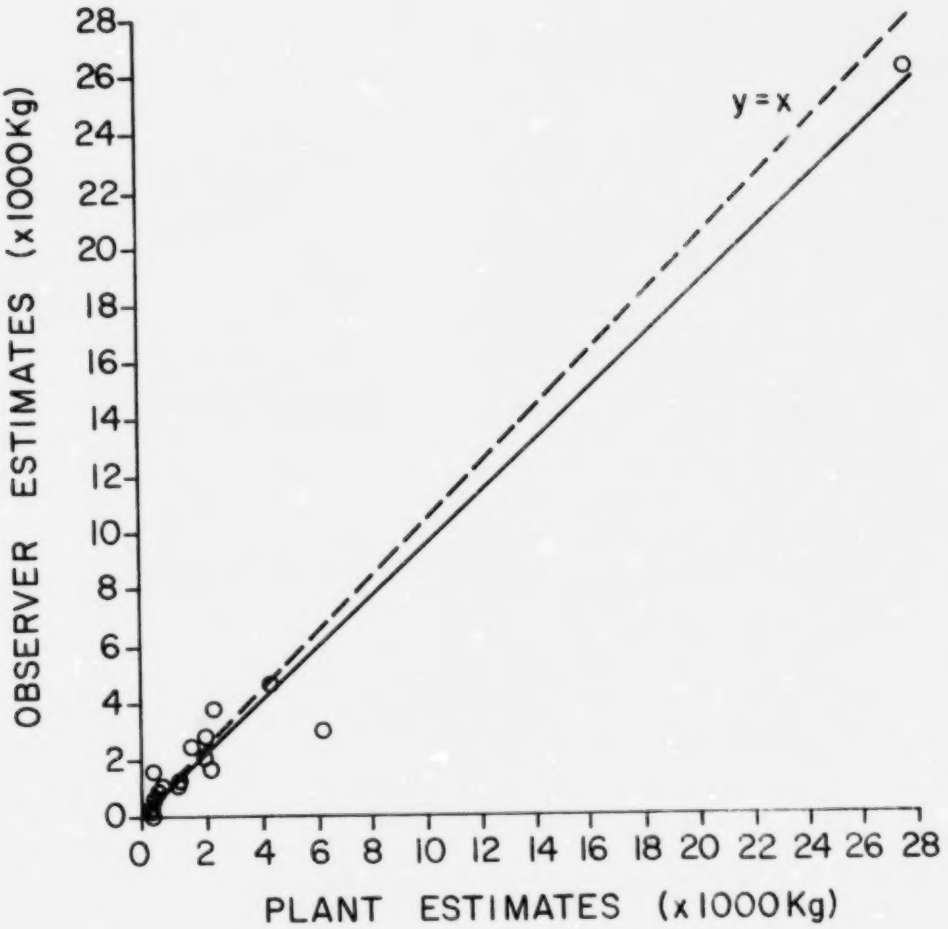

Fig. 5. Observer estimates versus fish plant estimates for English sole.

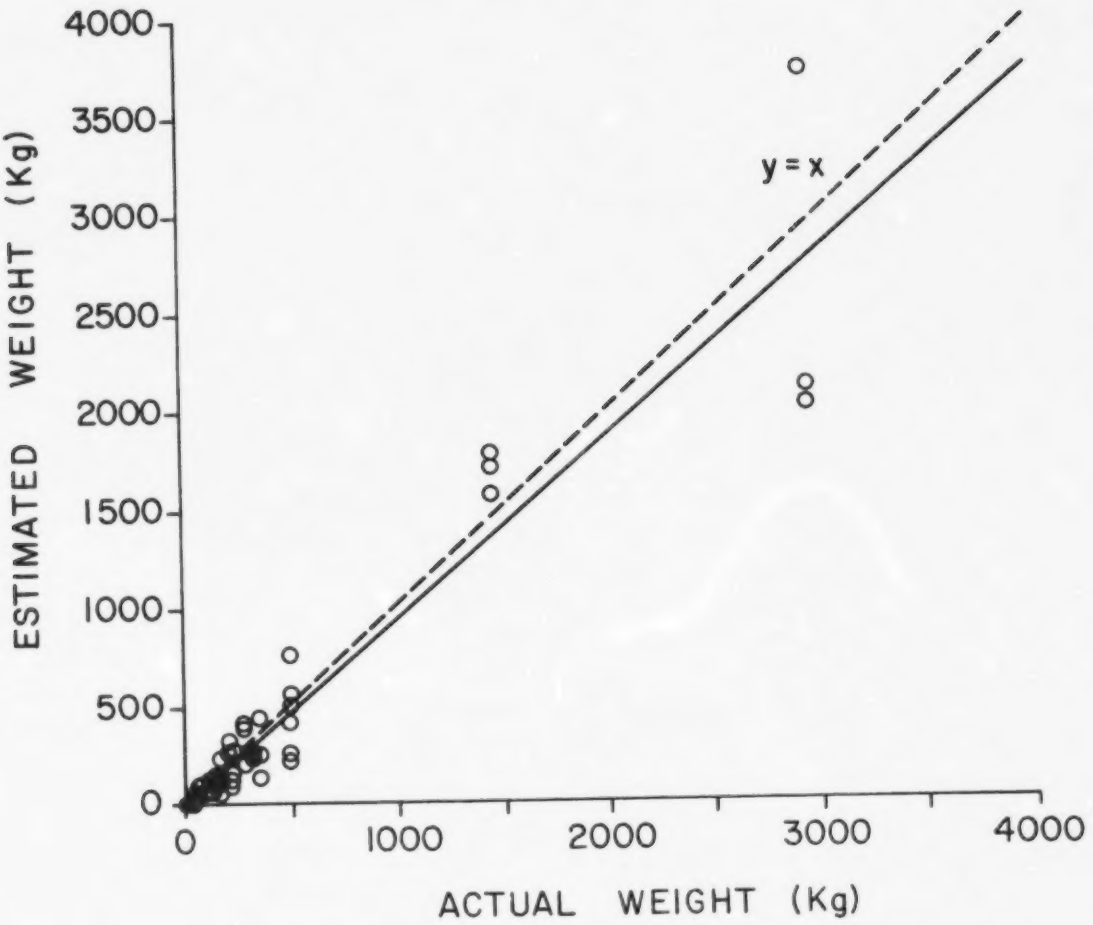

Fig. 6. Observer estimates versus actual weights of dogfish by individual tow.

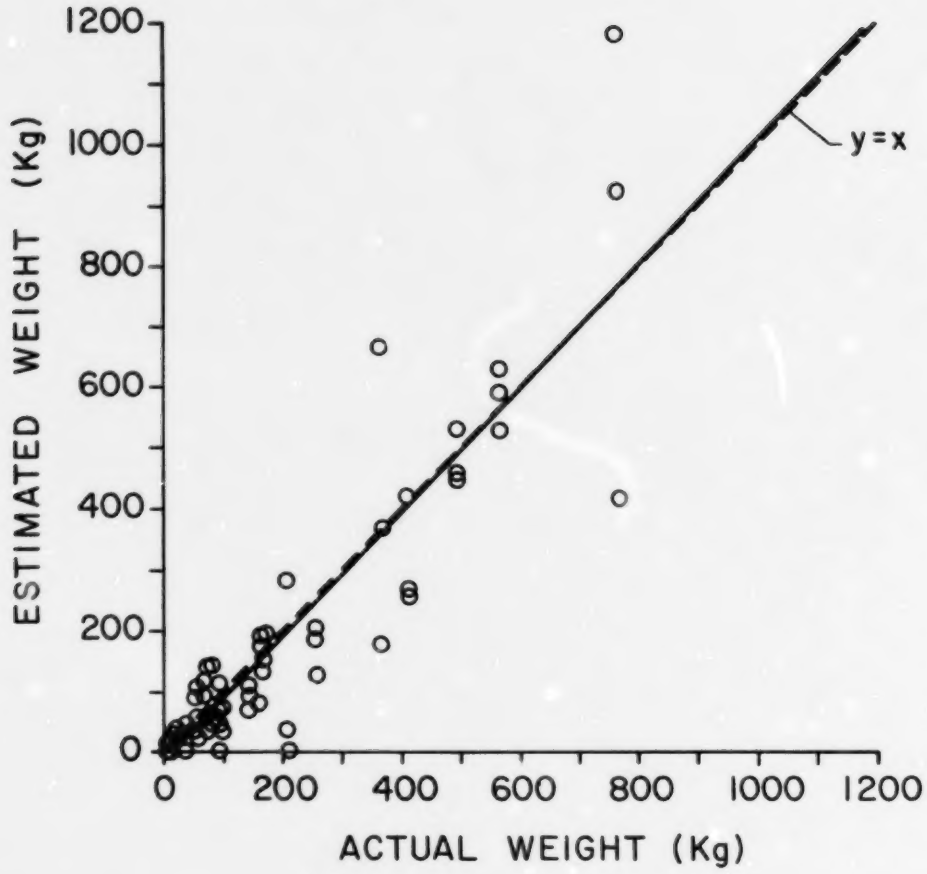

Fig. 7. Observer estimates versus actual weights of skate by individual tow.

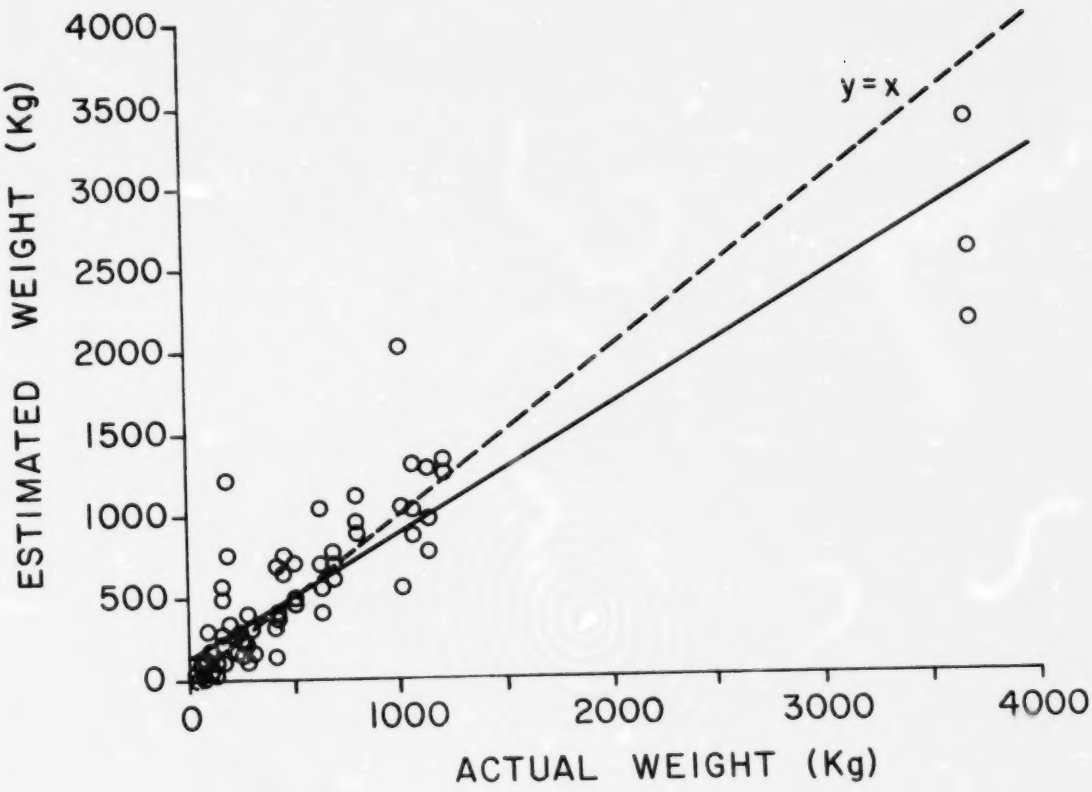

Fig. 8. Observer estimates versus actual weights of Pacific cod by individual tow.

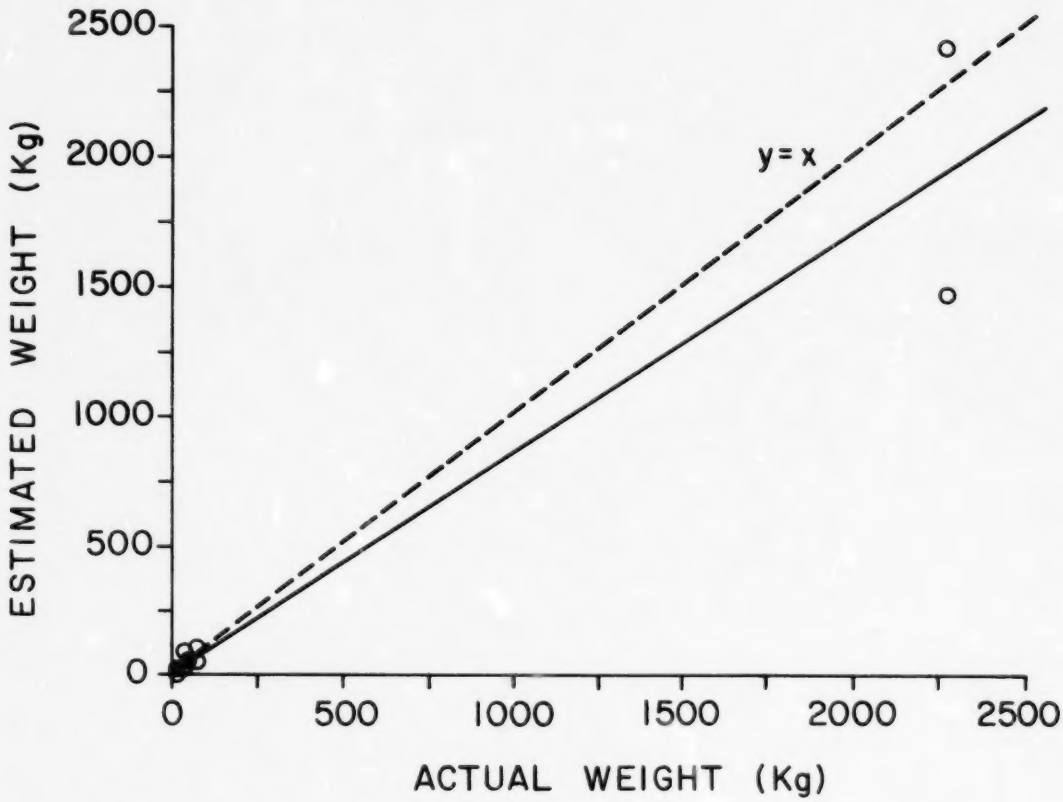

Fig. 9. Observer estimates versus actual weights of sablefish by individual tow.

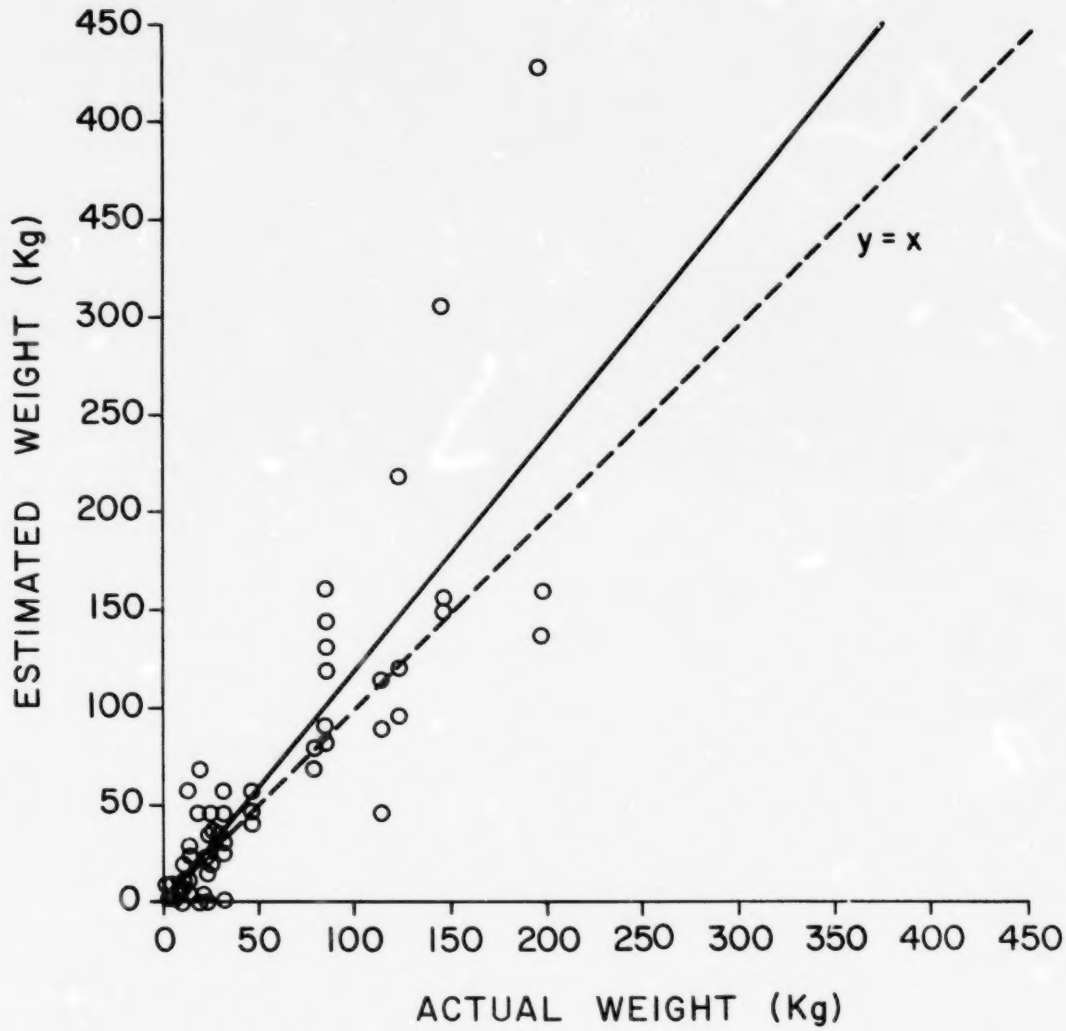

Fig. 10. Observer estimates versus actual weights of lingcod by individual tow.

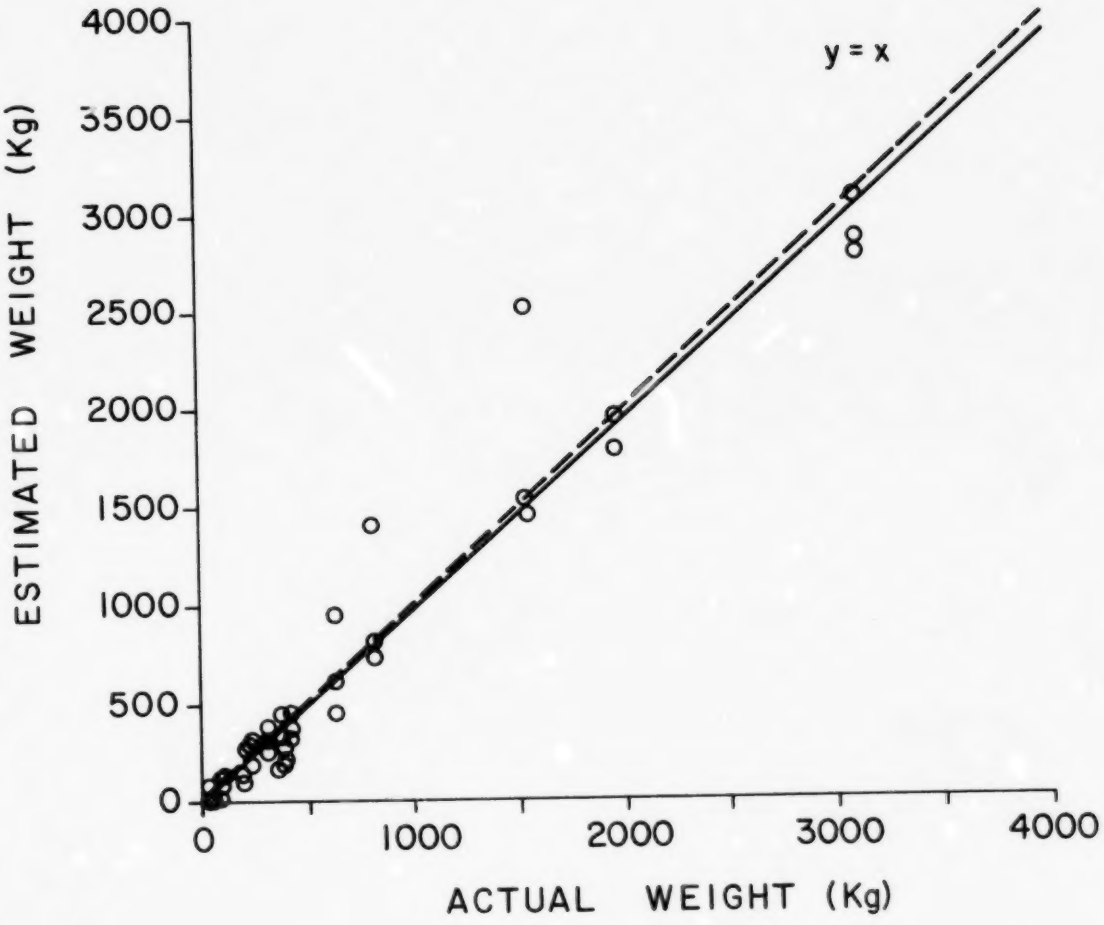

Fig. 11. Observer estimates versus actual weights of turbot by individual tow.

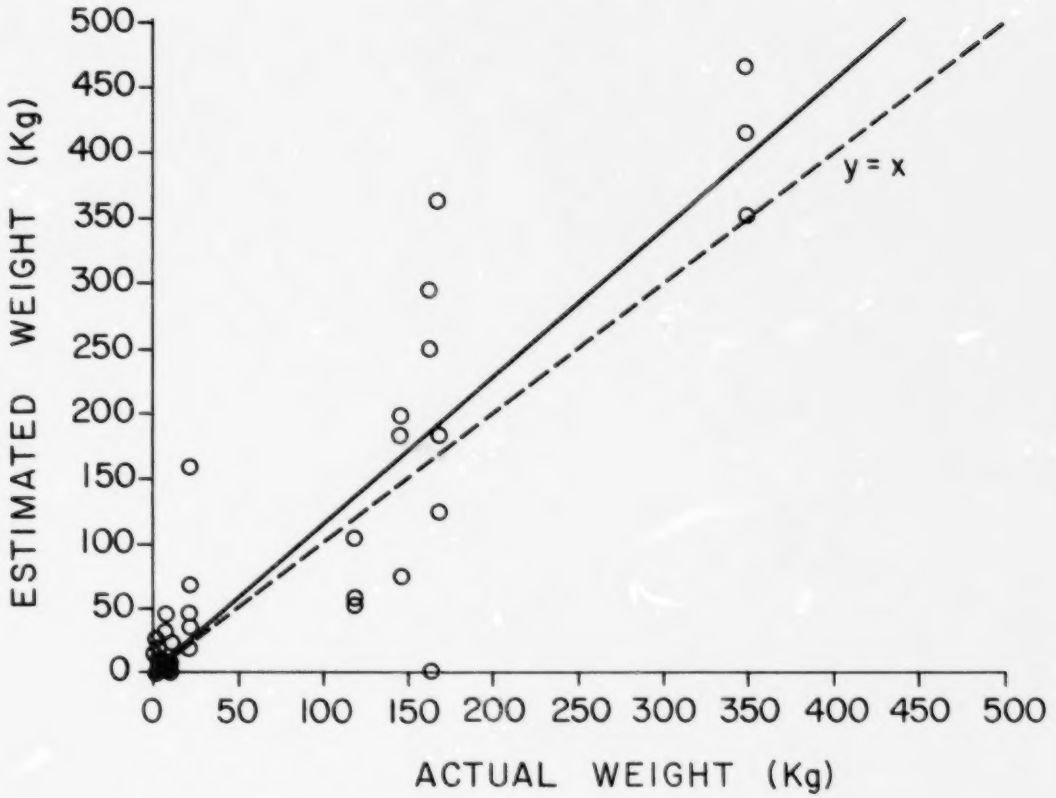

Fig. 12. Observer estimates versus actual weights of rock sole by individual tows.

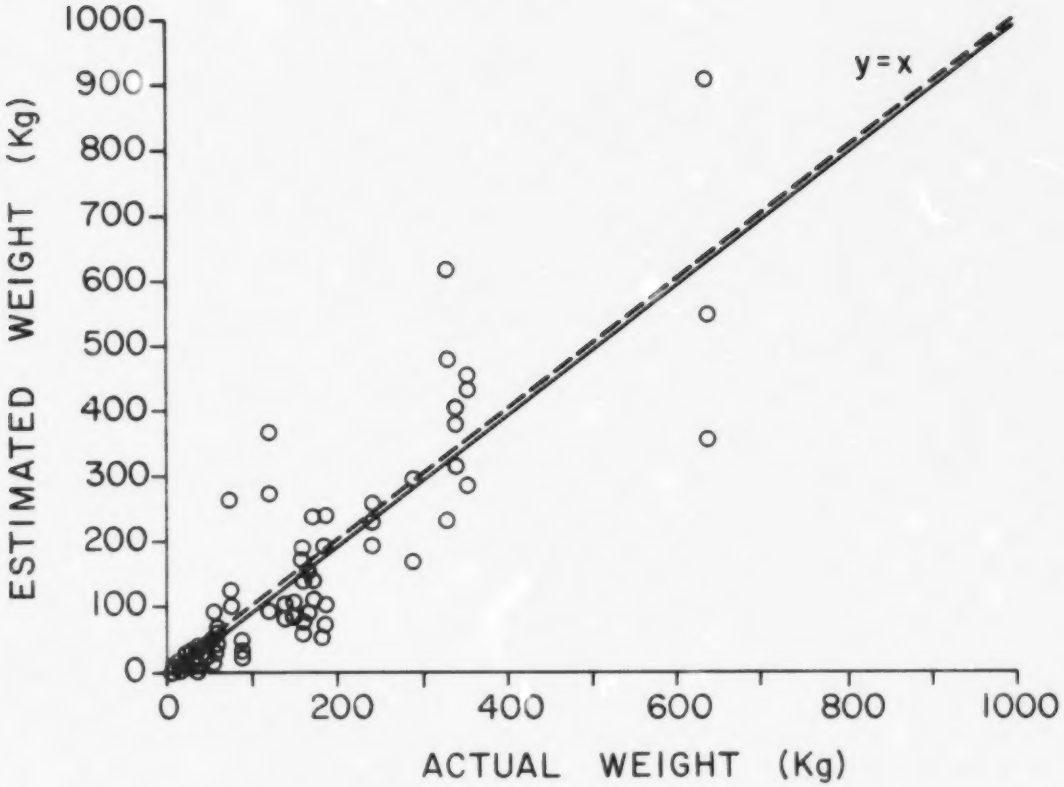

Fig. 13. Observer estimates versus actual weights of English sole by individual tows.

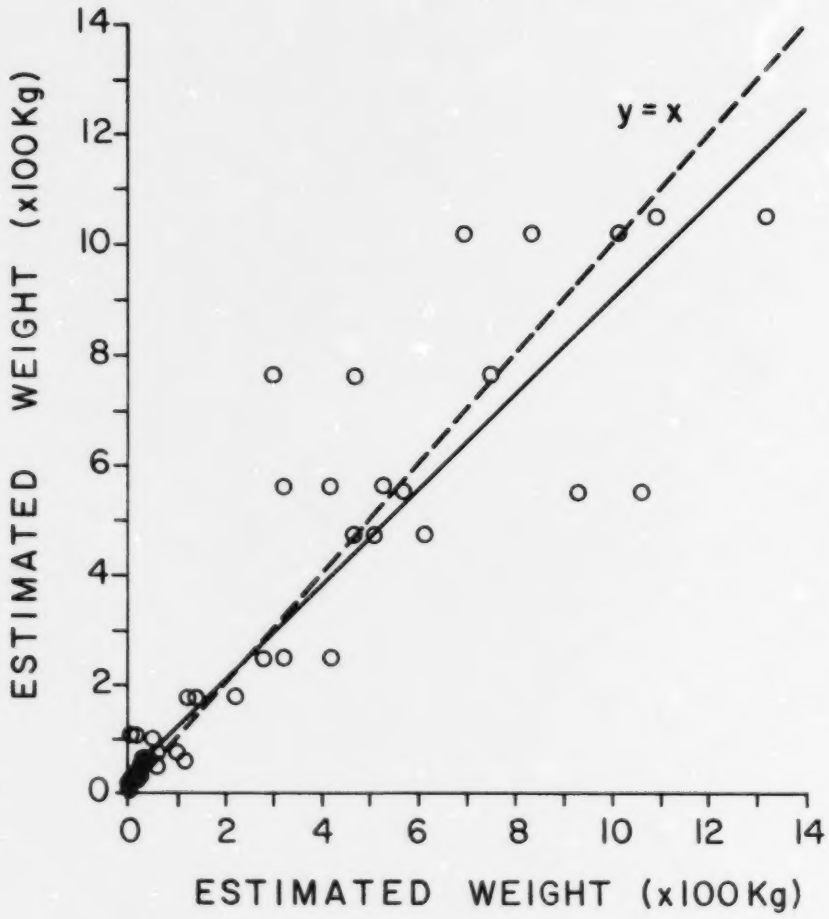

Fig. 14. Observer estimates versus actual weights for quantities less than 1400 kg.

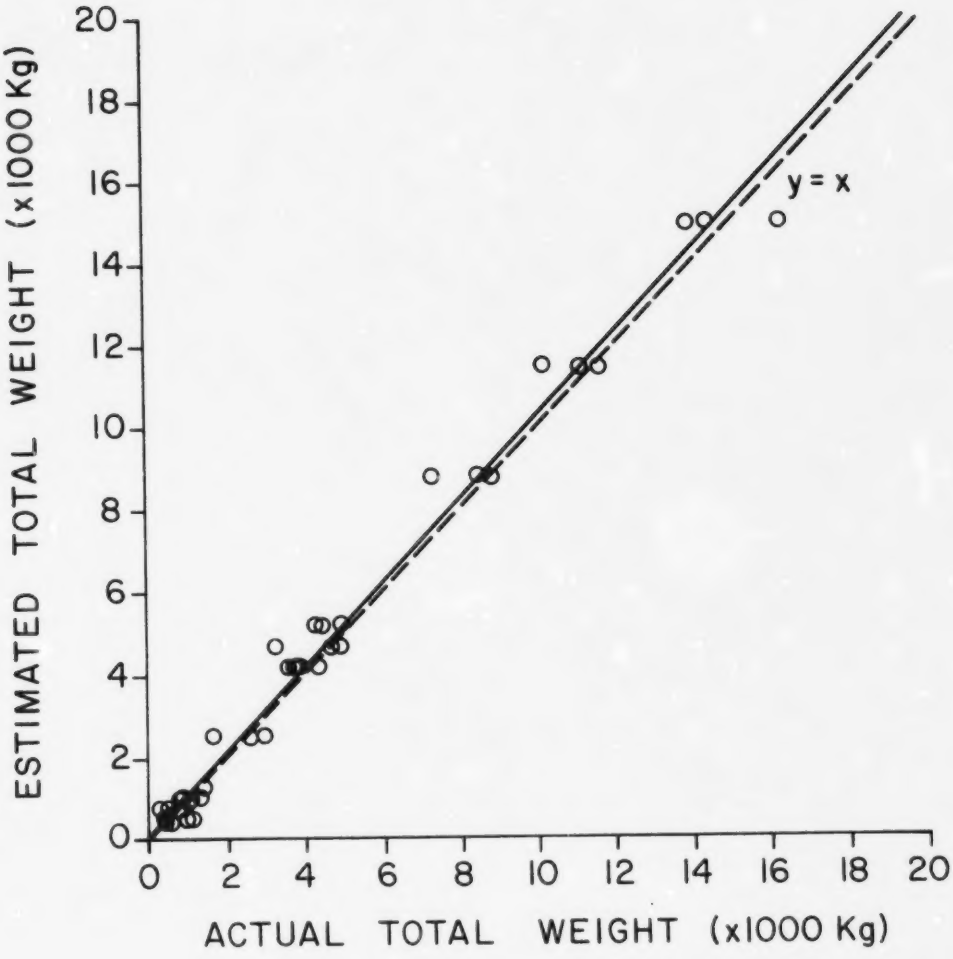

Fig. 15. Observer estimates versus actual weights for quantities between 250 and 17,000 kg.

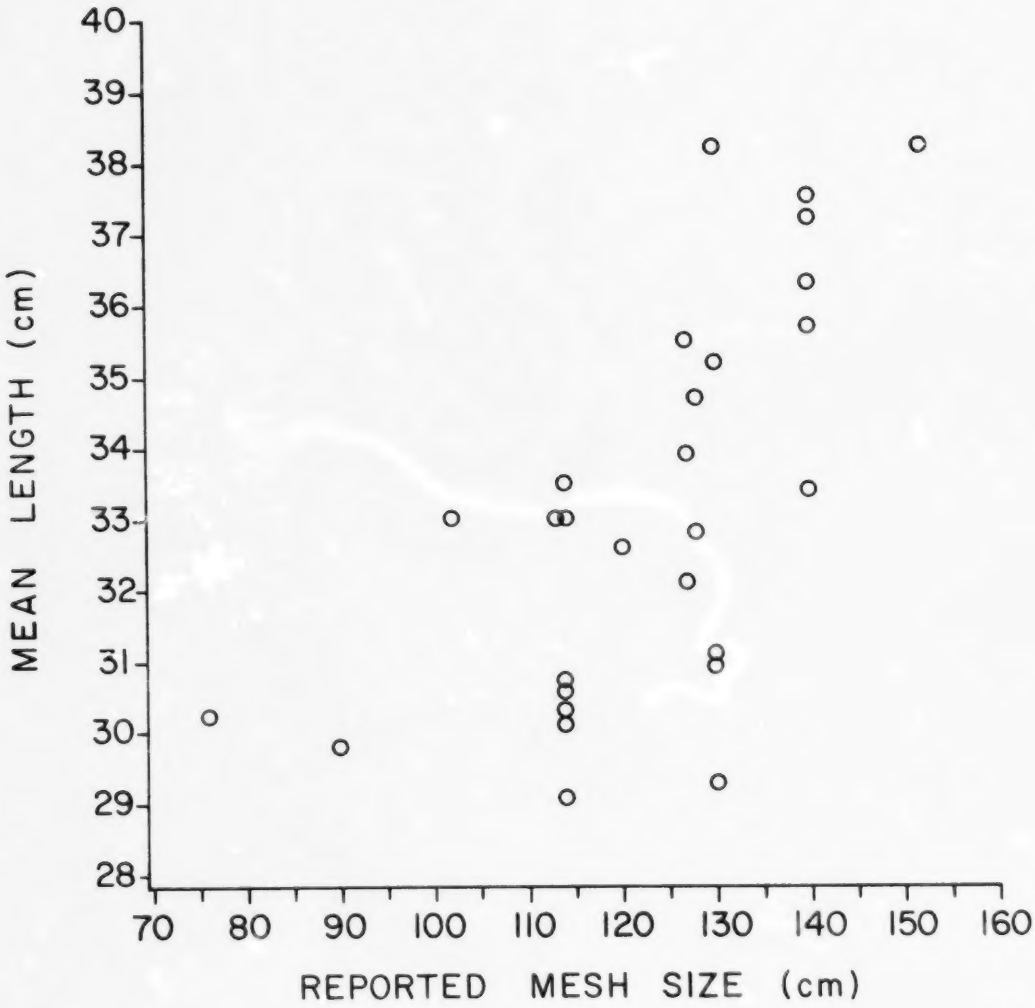

Fig. 16. Mean length (cm) of English sole versus reported mesh size by trip.

Appendix table 1. Size composition of Pacific cod (1981 and 1982).

Area	Q.C. Sd.	Q.C. Sd.	H. Str.	H. Str.	Q.C. Sd.	Q.C. Sd.	H. Str.	H. Str.
Year	1981	1981	1981	1981	1982	1982.	1982	1982
Sample type	Pre-sort	Discard	Pre-sort	Discard	Pre-sort	Discard	Pre-sort	Discard
Sex	M + F	M + F	M + F	M + F	M + F	M + F	M + F	M + F
Length								
18	0	0	0	0	0	0	1	0
19	0	0	0	0	0	0	3	0
20	0	0	0	0	0	0	5	0
21	0	0	0	0	0	0	11	0
22	0	0	0	0	0	0	21	0
23	0	1	2	0	0	0	34	0
24	0	0	0	0	0	0	31	0
25	1	1	5	0	0	0	19	0
26	0	4	8	0	0	0	8	0
27	1	1	8	0	0	0	5	0
28	0	7	10	0	1	0	1	0
29	0	6	21	1	0	1	0	1
30	3	6	19	3	0	0	4	5
31	2	8	28	0	0	2	5	3
32	5	13	20	1	0	0	6	5
33	4	11	23	3	0	0	6	3
34	6	17	27	4	1	0	3	11
35	6	15	36	6	2	1	6	5
36	13	28	47	13	2	2	3	9
37	15	53	63	13	7	5	7	6
38	15	66	86	37	6	6	8	4
39	23	63	85	40	13	5	12	15
40	24	84	114	49	15	7	21	11
41	37	90	129	47	14	9	18	29
42	33	94	133	62	24	7	28	20
43	31	77	125	55	29	12	20	25
44	40	68	148	69	33	11	42	26
45	23	55	124	43	38	9	36	18
46	37	42	120	21	40	8	30	8

Appendix table 1 (cont'd)

Area	Q.C. Sd.	Q.C. Sd.	H. Str.	H. Str.	Q.C. Sd.	Q.C. Sd.	H. Str.	H. Str.
Year	1981	1981	1981	1981	1982	1982.	1982	1982
Sample type	Pre-sort	Discard	Pre-sort	Discard	Pre-sort	Discard	Pre-sort	Discard
Sex	M + F	M + F	M + F	M + F	M + F	M + F	M + F	M + F
Length								
47	29	26	110	4	42	5	45	11
48	24	16	81	1	50	2	52	21
49	28	7	77	0	57	0	64	7
50	26	9	76	1	56	2	62	4
51	23	5	67	0	74	0	79	1
52	38	1	67	0	57	0	92	2
53	46	0	78	0	86	0	114	0
54	65	0	88	0	82	0	113	1
55	61	0	83	0	96	0	122	1
56	87	0	78	0	97	0	140	0
57	59	1	95	0	87	1	150	0
58	67	0	92	0	80	0	153	0
59	89	0	100	0	76	0	170	0
60	63	0	94	0	93	0	159	0
61	67	0	108	0	72	0	177	0
62	70	0	100	0	63	0	169	0
63	53	0	93	0	58	0	160	0
64	54	0	104	0	47	0	158	0
65	42	0	107	0	49	0	142	0
66	53	0	103	0	28	0	133	0
67	45	0	97	0	37	0	114	0
68	49	0	71	0	23	0	104	0
69	63	0	56	0	23	0	109	0
70	46	0	63	0	13	0	99	0
71	43	0	50	0	12	0	99	0
72	42	0	35	0	4	0	59	0
73	30	0	35	0	8	0	59	0
74	21	0	23	0	4	0	56	0
75	29	0	11	0	7	0	40	0

Appendix table 1 (cont'd)

Area	Q.C. Sd.	Q.C. Sd.	H. Str.	H. Str.	Q.C. Sd.	Q.C. Sd.	H. Str.	H. Str.
Year	1981	1981	1981	1981	1982	1982.	1982	1982
Sample type	Pre-sort	Discard	Pre-sort	Discard	Pre-sort	Discard	Pre-sort	Discard
Sex	M + F	M + F	M + F	M + F	M + F	M + F	M + F	M + F
Length								
76	14	0	11	0	5	0	29	0
77	9	0	10	0	1	0	22	0
78	7	0	6	0	4	0	19	0
79	7	0	5	0	2	0	13	0
80	2	0	5	0	3	0	8	0
81	1	0	1	0	2	0	4	0
82	1	0	5	0	2	0	7	0
83	1	0	2	0	3	0	5	0
84	1	0	0	0	1	0	3	0
85	0	0	1	0	0	0	5	0
86	1	0	1	0	0	0	3	0
Total	1775	875	3670	473	1729	95	3705	252

Appendix table 2. Size composition of sablefish (1981 and 1982).

Area	Q.C. Sd.	Q.C. Sd.	Q.C. Sd.	H. Str.	H. Str.	H. Str.	H. Str.	H. Str.	H. Str.
Year	1981	1981	1981	1981	1981	1981	1982	1982	1982
Sample type	Pre-sort	Pre-sort	Pre-sort	Pre-sort	Pre-sort	Pre-sort	Pre-sort	Pre-sort	Pre-sort
Sex	M + F	M	F	M + F	M	F	M + F	M	F
Length									
24	0	0	0	0	0	0	2	0	0
25	0	0	0	0	0	0	6	0	0
26	1	0	0	0	0	0	24	1	1
27	2	0	0	1	0	0	50	1	5
28	8	0	0	0	0	0	41	5	4
29	12	1	0	3	1	1	44	7	8
30	25	0	1	2	0	1	31	8	13
31	25	2	2	9	6	1	34	19	8
32	34	5	5	10	6	2	33	8	10
33	30	6	4	20	10	7	36	15	15
34	18	13	5	15	8	5	24	11	10
35	29	18	10	14	3	5	23	11	11
36	20	14	6	11	2	2	19	9	10
37	10	6	4	10	5	0	14	5	6
38	5	4	1	3	1	0	17	4	4
39	6	1	5	5	1	1	24	3	4
40	12	11	1	5	0	0	38	15	6
41	11	9	2	7	0	0	73	38	23
42	20	17	2	4	0	1	72	34	29
43	17	15	2	13	3	2	82	34	39
44	16	12	4	17	4	4	56	25	25
45	17	13	4	22	12	2	44	20	19
46	17	15	1	25	11	4	27	13	11
47	11	8	3	69	34	11	12	8	2
48	15	9	5	78	37	13	21	11	6
49	15	14	1	112	60	26	26	13	8
50	12	7	5	104	50	31	16	9	3
51	14	9	5	107	48	36	11	5	4
52	7	4	3	87	38	31	10	6	2

Appendix table 2 (cont'd)

Area	O.C. Sd.	Q.C. Sd.	O.C. Sd.	H. Str.	H. Str.	H. Str.	H. Str.	H. Str.	H. Str.
Year	1981	1981	1981	1981	1981	1981	1982	1982	1982
Sample type	Pre-sort	Pre-sort	Pre-sort	Pre-sort	Pre-sort	Pre-sort	Pre-sort	Pre-sort	Pre-sort
Sex	M + F	M	F	M + F	M	F	M + F	M	F
Length									
53	7	5	2	51	13	23	13	4	9
54	6	5	1	34	13	13	7	0	4
55	3	1	2	27	5	15	3	1	1
56	0	0	0	16	3	9	1	0	1
57	0	0	0	11	1	6	1	0	1
58	1	0	0	11	1	6	2	0	0
59	0	0	0	4	0	2	1	0	0
60	1	0	1	3	0	1	0	0	0
61	0	0	0	5	0	3	0	0	0
62	0	0	0	1	0	1	0	0	0
63	0	0	0	1	1	0	0	0	0
64	0	0	0	1	0	1	0	0	0
65	0	0	0	1	1	0	0	0	0
66	0	0	0	2	0	1	0	0	0
67	0	0	0	0	0	0	0	0	0
68	0	0	0	0	0	0	0	0	0
69	0	0	0	0	0	0	0	0	0
70	0	0	0	0	0	0	0	0	0
71	0	0	0	1	0	0	0	0	0
Total	427	224	87	922	378	267	938	343	302

Appendix table 3. Size composition of rock sole (1981).

Area	Q.C. Sd.	Q.C. Sd.	H. Str.	H. Str.	H. Str.	H. Str.	H. Str.	H. Str.	H. Str.	H. Str.
Year	1981	1981	1981	1981	1981	1981	1981	1981	1981	1981
Sample type	Pre-sort	Discard	Pre-sort	Pre-sort	Pre-sort	Discard	Discard	Discard	Discard	Keeper
Sex	M + F	M + F	M + F	M	F	M + F	M	F	IMM	M + F
Length										
13	0	0	0	0	0	2	0	0	0	0
14	0	0	1	0	0	4	0	1	5	0
15	0	0	1	0	0	3	0	0	3	0
16	0	0	1	0	0	2	0	0	2	0
17	0	0	5	0	0	9	5	2	2	0
18	0	0	9	0	1	14	4	4	6	0
19	1	0	10	0	0	29	13	12	4	0
20	0	2	20	2	4	36	7	18	11	0
21	0	5	17	0	3	39	11	22	5	0
22	0	9	17	0	3	32	9	20	2	0
23	0	17	29	0	4	29	11	16	2	0
24	4	21	39	2	3	34	21	12	0	0
25	17	22	58	6	6	59	32	23	1	0
26	11	29	115	14	17	129	59	65	2	0
27	18	35	122	15	10	209	110	92	0	0
28	33	33	184	20	19	243	123	105	0	0
29	41	29	236	18	25	206	107	87	0	0
30	44	39	294	30	33	108	53	45	0	1
31	42	43	328	30	28	68	41	17	0	0
32	38	28	308	25	47	29	15	8	0	1
33	22	35	328	28	37	7	1	2	0	7
34	32	26	295	36	33	3	0	0	0	5
35	25	10	287	36	34	2	0	0	0	7
36	18	7	266	20	19	2	0	0	0	8
37	11	5	238	10	23	0	0	0	0	8
38	11	1	198	4	18	1	0	0	0	11
39	13	2	171	3	26	0	0	0	0	9
40	20	0	168	2	24	0	0	0	0	6
41	17	0	150	0	26	0	0	0	0	4

Appendix table 3 (cont'd)

Area	Q.C. Sd.	Q.C. Sd.	H. Str.	H. Str.	H. Str.	H. Str.	H. Str.	H. Str.	H. Str.	H. Str.
Year	1981	1981	1981	1981	1981	1981	1981	1981	1981	1981
Sample type	Pre-sort	Discard	Pre-sort	Pre-sort	Pre-sort	Discard	Discard	Discard	Discard	Keeper
Sex	M + F	M + F	M + F	M	F	M + F	M	F	IMM	M + F
Length										
42	17	0	144	0	23	0	0	0	0	1
43	17	0	126	0	20	0	0	0	0	4
44	18	0	115	0	21	0	0	0	0	0
45	12	0	85	0	14	0	0	0	0	2
46	7	0	72	0	11	0	0	0	0	0
47	6	0	49	0	7	0	0	0	0	2
48	8	0	39	0	5	0	0	0	0	0
49	2	0	26	0	2	0	0	0	0	0
50	1	0	21	0	3	0	0	0	0	1
51	0	0	7	0	1	0	0	0	0	0
52	1	0	10	0	2	0	0	0	0	0
53	0	0	2	0	1	0	0	0	0	0
54	1	0	3	0	0	0	0	0	0	0
55	0	0	3	0	1	0	0	0	0	0
56	0	0	0	0	0	0	0	0	0	0
Total	508	398	4597	301	554	1299	622	551	45	77

Appendix table 4. Size composition of rock sole (1982).

Area	Q.C. Sd.	Q.C. Sd.	Q.C. Sd.	Q.C. Sd.	Q.C. Sd.	Q.C. Sd.	H. Str.	H. Str.	H. Str.	H. Str.	H. Str.	H. Str.	H. Str.
Year	1982	1982	1982	1982	1982	1982	1982	1982	1982	1982	1982	1982	1982
Sample type	Pre-sort	Pre-sort	Pre-sort	Discard	Discard	Keeper	Pre-sort	Pre-sort	Pre-sort	Discard	Discard	Discard	Keeper
Sex	M + F	M	F	M	F	M + F	M + F	M	F	M + F	M	F	M + F
Length													
13	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	1	0	0	0
18	0	0	0	0	0	0	1	0	0	1	0	0	0
19	0	0	0	0	0	0	2	1	0	5	0	0	0
20	0	0	0	0	0	0	4	1	0	12	0	2	0
21	2	1	1	0	0	0	8	2	1	20	1	1	0
22	4	3	1	0	4	0	18	4	1	36	7	2	0
23	4	3	1	4	8	0	16	1	2	62	9	5	0
24	23	8	15	4	6	0	24	6	2	54	8	8	0
25	22	9	13	5	12	0	13	5	1	62	9	13	0
26	33	16	17	8	8	0	18	4	2	68	12	16	0
27	45	16	29	9	12	0	24	7	3	71	16	12	0
28	44	19	25	8	8	0	16	6	1	62	9	18	0
29	47	22	25	6	13	0	16	3	0	54	9	16	0
30	49	13	36	3	15	0	17	4	2	45	12	12	1
31	29	9	20	2	13	2	11	0	0	16	4	5	2
32	30	10	20	1	8	1	21	5	0	20	6	4	7
33	32	11	21	2	8	0	22	2	0	15	4	4	11
34	28	10	18	1	4	5	20	3	1	4	0	1	13
35	33	4	4	0	1	2	22	3	4	8	2	3	20
36	37	0	0	0	0	6	18	0	2	3	1	0	23
37	27	0	1	0	0	0	8	0	1	0	0	0	33
38	26	0	0	0	0	1	13	0	3	2	2	0	22
39	21	0	0	0	0	10	12	1	2	2	0	0	24
40	29	0	0	0	0	5	14	0	2	0	0	0	31
41	37	0	0	0	0	8	19	0	2	0	0	0	27

Appendix table 4 (cont'd)

Area	Q.C. Sd.	Q.C. Sd.	Q.C. Sd.	Q.C. Sd.	Q.C. Sd.	Q.C. Sd.	H. Str.	H. Str.	H. Str.	H. Str.	H. Str.	H. Str.	H. Str.
Year	1982	1982	1982	1982	1982	1982	1982	1982	1982	1982	1982	1982	1982
Sample type	Pre-sort	Pre-sort	Pre-sort	Discard	Discard	Keeper	Pre-sort	Pre-sort	Pre-sort	Discard	Discard	Discard	Keeper
Sex	M + F	M	F	M	F	M + F	M + F	M	F	M + F	M	F	M + F
Length													
42	33	0	0	0	0	14	13	0	2	0	0	0	32
43	42	0	0	0	0	8	9	0	0	0	0	0	35
44	25	0	0	0	0	9	11	0	1	0	0	0	34
45	31	0	0	0	0	16	11	0	3	0	0	0	42
46	11	0	0	0	0	20	5	0	1	0	0	0	31
47	17	0	0	0	0	10	5	0	1	0	0	0	26
48	20	0	0	0	0	6	3	0	0	0	0	0	23
49	16	0	0	0	0	8	5	0	1	0	0	0	21
50	5	0	0	0	0	9	2	0	0	0	0	0	13
51	3	0	0	0	0	2	3	0	2	0	0	0	10
52	3	0	0	0	0	5	0	0	0	0	0	0	5
53	4	0	0	0	0	1	1	0	1	0	0	0	4
54	2	0	0	0	0	1	0	0	0	0	0	0	0
55	0	0	0	0	0	0	0	0	0	0	0	0	0
56	0	0	0	0	0	0	0	0	0	0	0	0	1
57	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	814	154	247	53	120	149	425	58	44	624	111	122	491

Appendix table 5. Size composition of English sole (1981).

Area	Q.C. Sd.	Q.C. Sd.	Q.C. Sd.	Q.C. Sd.	H. Str.	H. Str.	H. Str.	H. Str.	H. Str.	H. Str.	H. Str.
Year	1981	1981	1981	1981	1981	1981	1981	1981	1981	1981	1981
Sample type	Pre-sort	Pre-sort	Pre-sort	Discard	Pre-sort	Pre-sort	Pre-sort	Discard	Discard	Discard	Keeper
Sex	M + F	M	F	M + F	M + F	M	F	M + F	M	F	M + F
Length											
14	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	1	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	2	0	0	2	0	0	0
18	0	0	0	1	8	0	0	9	2	1	0
19	0	0	0	6	41	0	0	12	0	1	0
20	0	0	0	12	38	0	1	28	2	3	0
21	1	0	0	35	45	0	0	25	7	3	0
22	2	0	0	39	32	0	0	20	5	1	0
23	9	0	0	59	48	0	0	35	12	4	0
24	26	0	0	67	89	0	0	42	16	7	0
25	59	2	1	61	136	2	1	82	32	10	0
26	84	1	3	71	196	0	3	82	28	19	1
27	126	6	4	77	243	1	1	141	58	25	2
28	166	12	4	88	313	4	3	162	53	23	0
29	184	17	5	68	377	1	2	188	61	36	6
30	233	23	6	60	438	2	0	158	45	28	11
31	205	28	10	55	440	3	2	162	61	31	28
32	195	24	13	25	432	3	5	103	32	24	37
33	155	27	21	19	441	7	2	47	21	5	40
34	174	27	20	17	370	1	7	20	10	3	39
35	185	24	21	22	341	1	12	11	7	0	35
36	153	13	14	11	296	6	3	6	3	0	23
37	152	13	15	7	275	0	7	3	0	2	22
38	88	5	8	10	207	2	4	1	0	0	16
39	42	3	6	5	219	0	9	2	1	0	11
40	39	1	3	7	165	0	8	0	0	0	12
41	34	0	4	0	115	0	5	0	0	0	6
42	25	0	3	0	108	0	9	0	0	0	4

Appendix table 5 (cont'd)

Area	Q.C. Sd.	Q.C. Sd.	Q.C. Sd.	Q.C. Sd.	H. Str.	H. Str.	H. Str.	H. Str.	H. Str.	H. Str.	H. Str.
Year	1981	1981	1981	1981	1981	1981	1981	1981	1981	1981	1981
Sample type	Pre-sort	Pre-sort	Pre-sort	Discard	Pre-sort	Pre-sort	Pre-sort	Discard	Discard	Discard	Keeper
Sex	M + F	M	F	M + F	M + F	M	F	M + F	M	F	M + F
Length											
43	21	0	1	0	71	0	5	0	0	0	2
44	9	0	1	0	49	0	4	0	0	0	1
45	10	0	1	0	35	0	0	0	0	0	3
46	7	0	0	0	34	0	3	0	0	0	3
47	2	0	0	0	27	0	3	0	0	0	1
48	3	0	1	0	15	0	0	0	0	0	1
49	0	0	0	0	14	0	0	0	0	0	1
50	1	0	0	0	11	0	0	0	0	0	0
51	0	0	0	0	6	0	0	0	0	0	2
52	0	0	0	0	5	0	0	0	0	0	1
53	0	0	0	0	1	0	0	0	0	0	0
54	0	0	0	0	1	0	0	0	0	0	0
55	1	0	0	0	1	0	0	0	0	0	0
56	0	0	0	0	0	0	0	0	0	0	0
Total	2391	226	165	822	5685	33	99	1342	456	226	308

Appendix table 6. Size composition of English sole (1982).

Area	Q.C. Sd.	Q.C. Sd.	Q.C. Sd.	Q.C. Sd.	Q.C. Sd.	H. Str.	H. Str.	H. Str.	H. Str.	H. Str.	H. Str.	H. Str.
Year	1982	1982	1982	1982	1982	1982	1982	1982	1982	1982	1982	1982
Sample type	Pre-sort	Pre-sort	Pre-sort	Discard	Discard	Pre-sort	Pre-sort	Pre-sort	Discard	Discard	Discard	Keeper
Sex	M + F	M	F	M	F	M + F	M	F	M + F	M	F	M + F
Length												
14	0	0	0	0	0	1	1	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	1	0	0	0
17	0	0	0	0	0	0	0	0	1	0	0	0
18	0	0	0	0	0	3	2	0	2	0	0	0
19	0	0	0	0	0	5	4	0	3	0	0	0
20	2	1	0	0	0	15	13	0	2	2	0	0
21	5	2	1	0	1	41	28	8	8	5	2	0
22	7	6	1	0	0	45	28	11	21	7	11	0
23	19	6	10	0	0	71	40	16	30	13	9	0
24	29	16	11	0	4	78	49	9	56	26	23	0
25	66	36	21	4	2	115	59	35	82	37	30	0
26	90	53	30	0	9	131	76	33	78	31	27	0
27	125	74	43	4	7	141	70	43	89	50	28	0
28	128	65	53	7	6	199	96	65	136	65	45	1
29	159	79	73	5	7	183	76	72	144	72	44	1
30	143	76	55	1	10	226	108	75	176	73	63	5
31	172	70	94	0	8	258	118	99	184	64	67	18
32	148	55	86	2	16	297	150	118	139	52	57	53
33	162	60	62	0	8	302	110	98	85	35	37	67
34	121	38	48	0	11	312	104	105	54	19	32	90
35	105	34	31	2	9	383	136	125	41	17	22	104
36	114	10	12	0	1	295	77	129	12	5	7	93
37	88	13	14	2	0	270	50	104	5	4	1	104
38	72	7	5	0	0	304	8	71	0	0	0	106
39	45	3	6	0	1	236	8	54	0	0	0	112
40	42	4	5	0	1	230	2	71	0	0	0	102
41	37	1	6	0	0	156	0	56	0	0	0	104
42	23	0	5	0	0	129	0	46	0	0	0	79

Appendix table 6 (cont'd)

Area	Q.C. Sd.	Q.C. Sd.	Q.C. Sd.	Q.C. Sd.	Q.C. Sd.	H. Str.	H. Str.	H. Str.	H. Str.	H. Str.	H. Str.	H. Str.
Year	1982	1982	1982	1982	1982	1982	1982	1982	1982	1982	1982	1982
Sample type	Pre-sort	Pre-sort	Pre-sort	Discard	Discard	Pre-sort	Pre-sort	Pre-sort	Discard	Discard	Discard	Keeper
Sex	M + F	M	F	M	F	M + F	M	F	M + F	M	F	M + F
Length												
43	14	0	4	0	0	97	0	35	0	0	0	50
44	16	0	4	0	0	63	0	21	0	0	0	35
45	15	0	3	0	0	39	0	17	0	0	0	31
46	5	0	1	0	0	30	0	13	0	0	0	30
47	6	0	3	0	0	26	0	5	0	0	0	26
48	5	0	2	0	0	25	0	5	0	0	0	18
49	2	0	0	0	0	13	0	0	0	0	0	18
50	1	0	0	0	0	4	0	0	0	0	0	14
51	0	0	0	0	0	4	0	1	0	0	0	9
52	0	0	0	0	0	6	0	1	0	0	0	5
53	0	0	0	0	0	2	0	1	0	0	0	5
54	0	0	0	0	0	2	0	1	0	0	0	1
55	0	0	0	0	0	1	0	0	0	0	0	0
56	0	0	0	0	0	0	0	0	0	0	0	0
57	0	0	0	0	0	0	0	0	0	0	0	1
Total	1966	709	689	27	101	4738	1413	1543	1349	577	505	1282